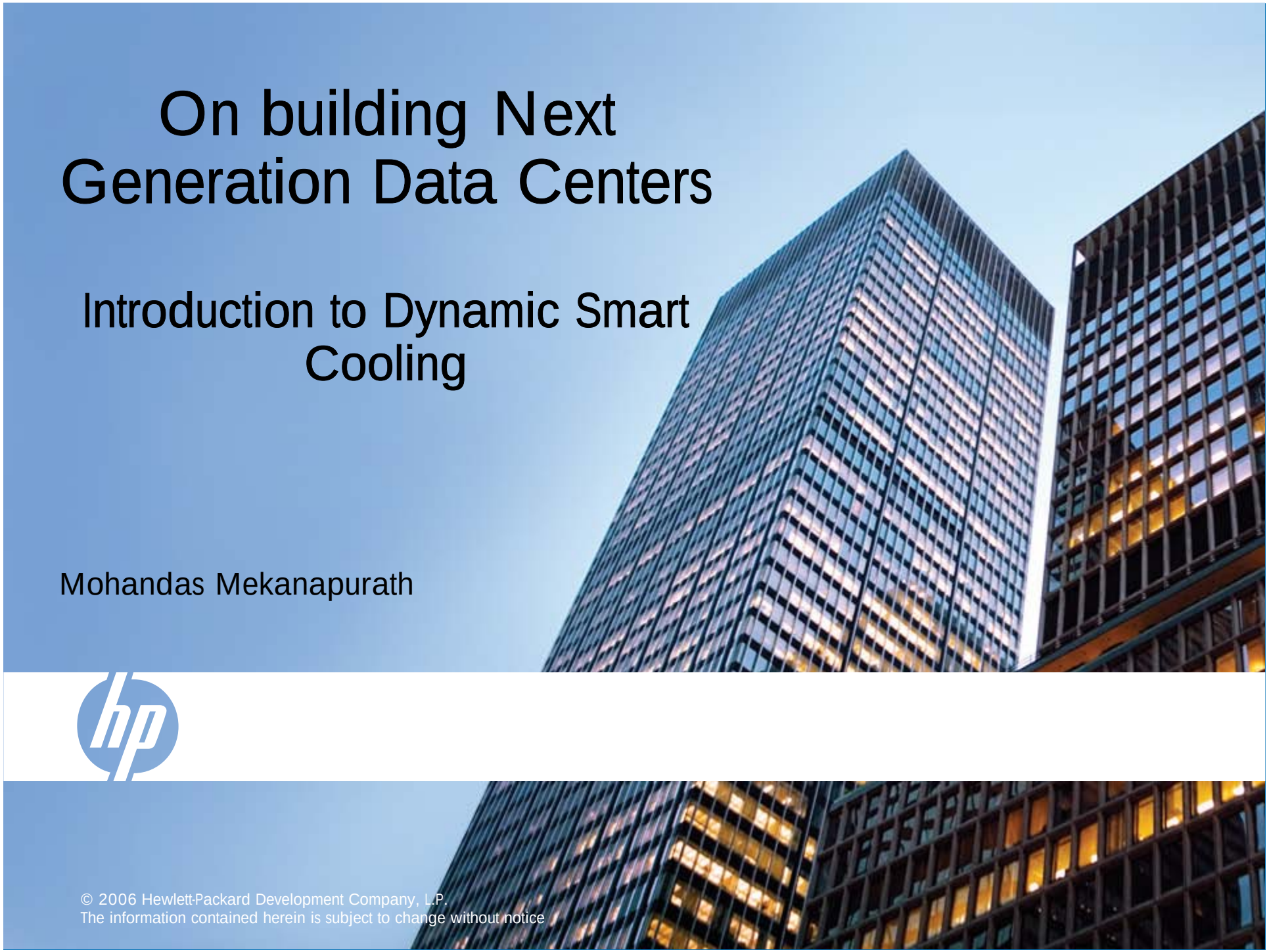
# On building Next Generation Data Centers

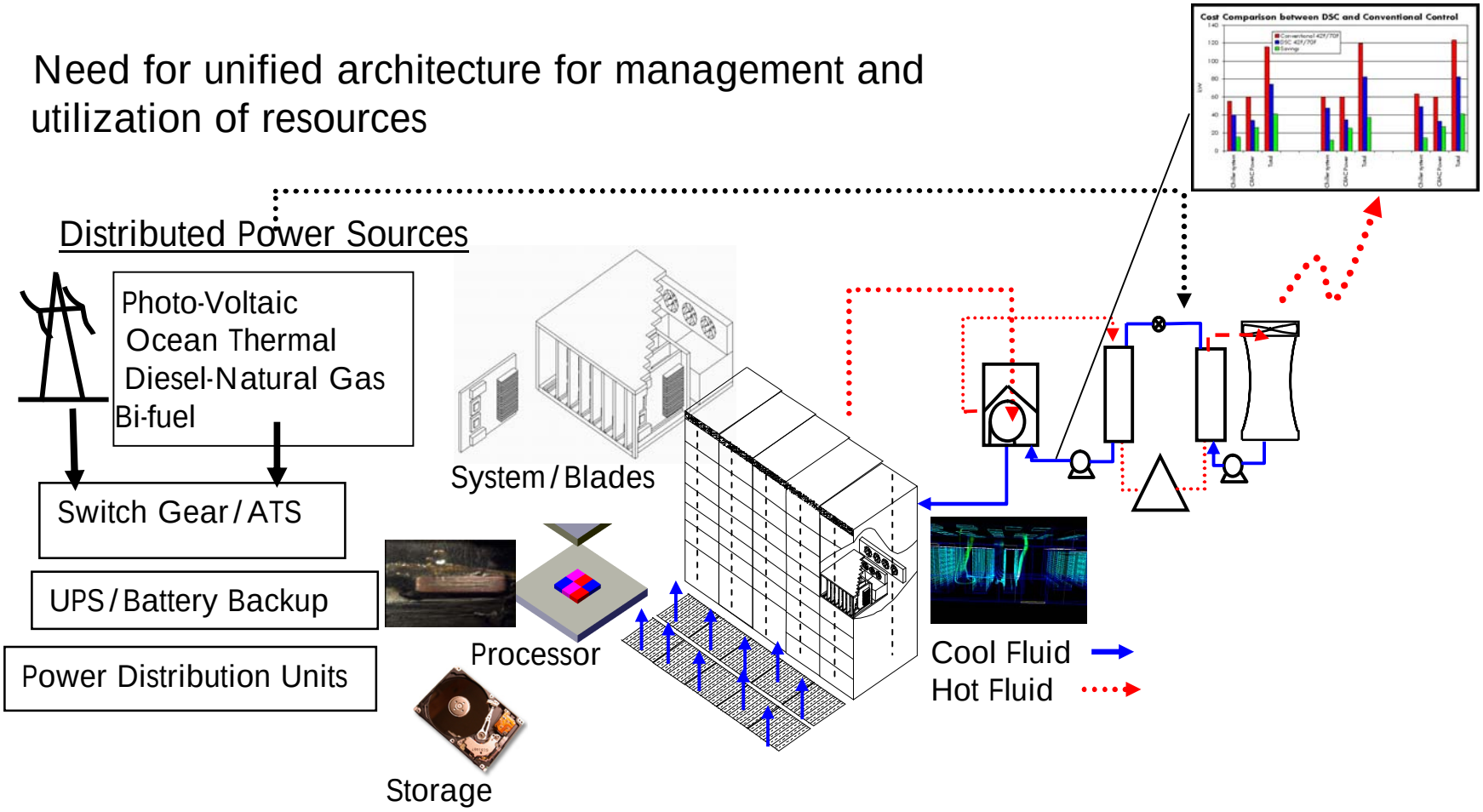
## Introduction to Dynamic Smart Cooling

Mohandas Mekanapurath



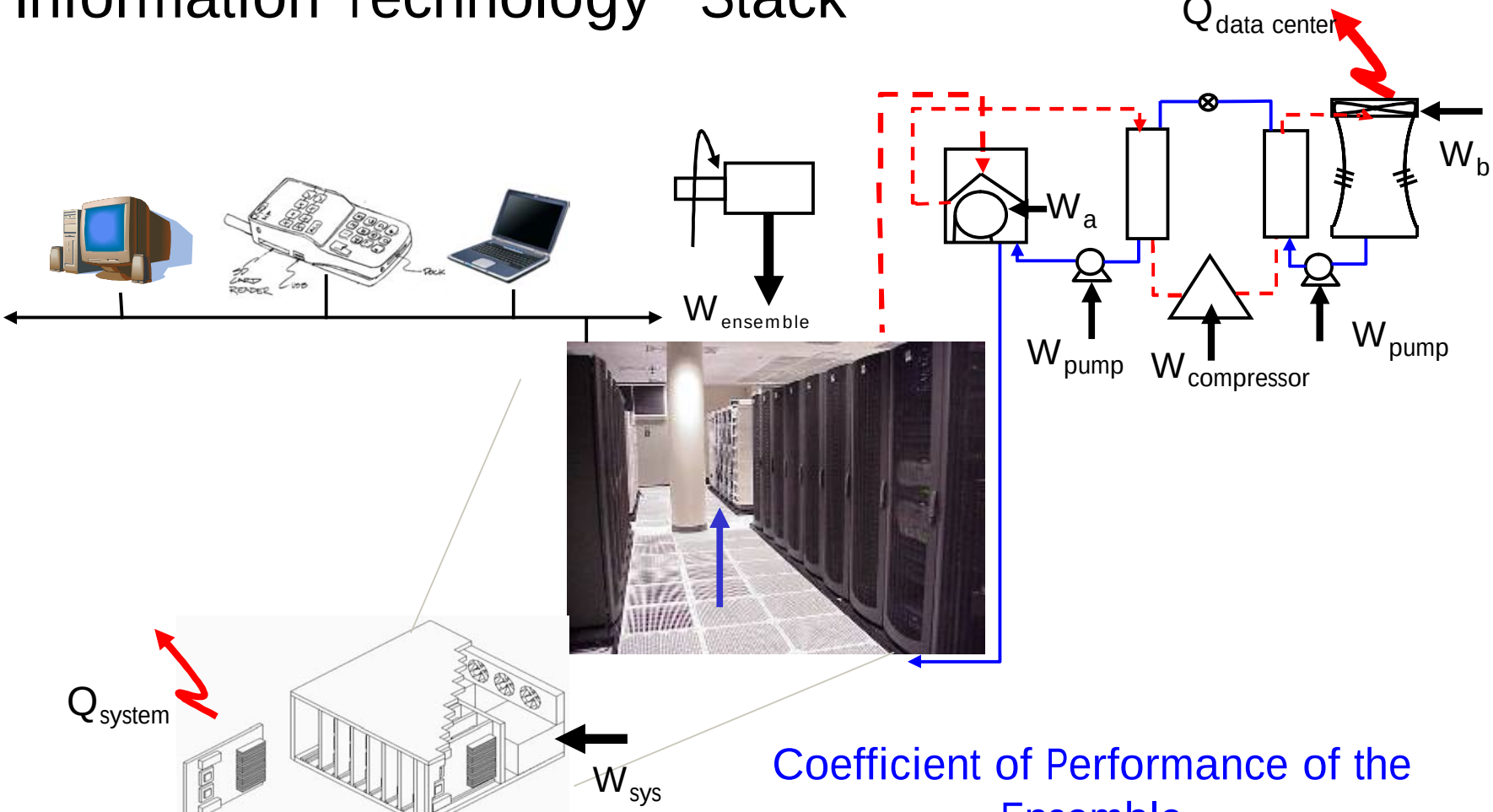
# Typical Information Technology-Facility Complex

Need for unified architecture for management and utilization of resources




- Control of resources from Device to Facility
- Requires Integrated Design of Systems and Facility

# Information Technology "Stack"

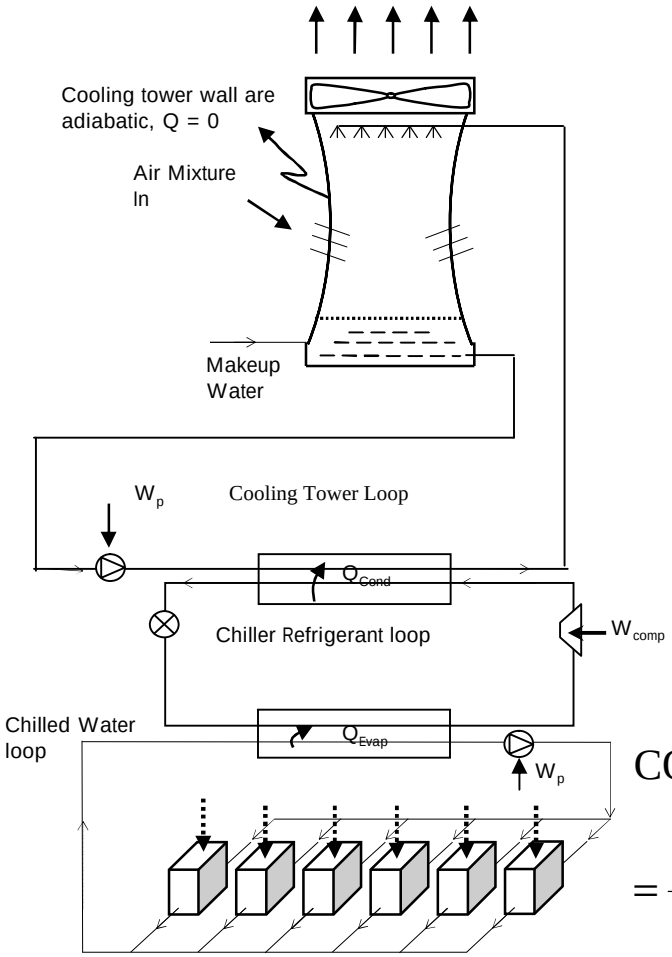



## Coefficient of Performance of the Ensemble

$$COP_{ensemble} = \frac{\text{Total Heat Dissipation}}{(\text{Flow Work} + \text{Thermodynamic Work}) \text{ of Cooling system}}$$

Patel et. al, Energy Flow in the Information Technology Stack: Coefficient of Performance of the Ensemble and its Impact on TCO
http://www.hpl.hp.com/techreports/2006/HPL-2006-55.html

# Chips to Cooling Tower – Ensemble Approach



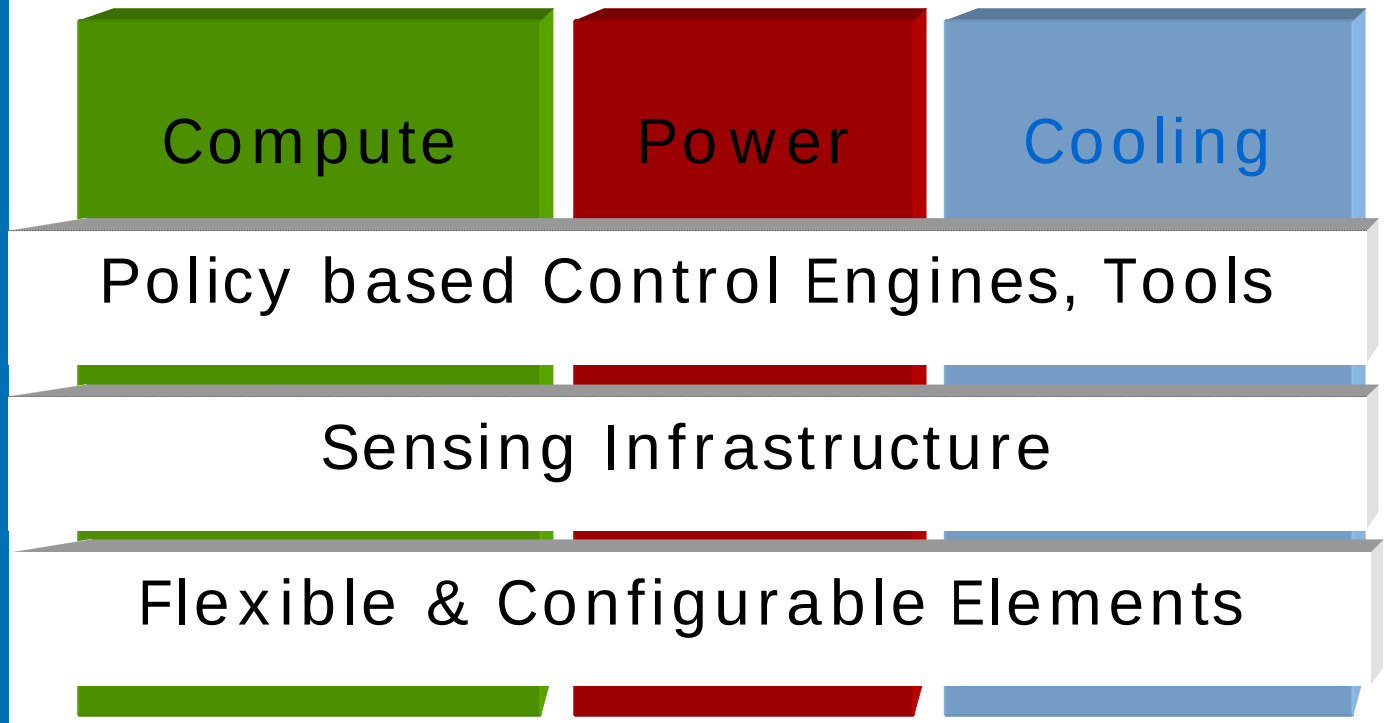

- Energy is a common "currency" which can be used to assess the performance of this ensemble at each stage.
- Overall reliability and availability and manageability of the ensemble is assessed by monitoring the robustness of energy flow in the datacenter.

$$COP = \frac{\text{Total Heat Dissipation}}{(\text{Flow Work} + \text{Thermodynamic Work}) \text{ of Cooling system}}$$

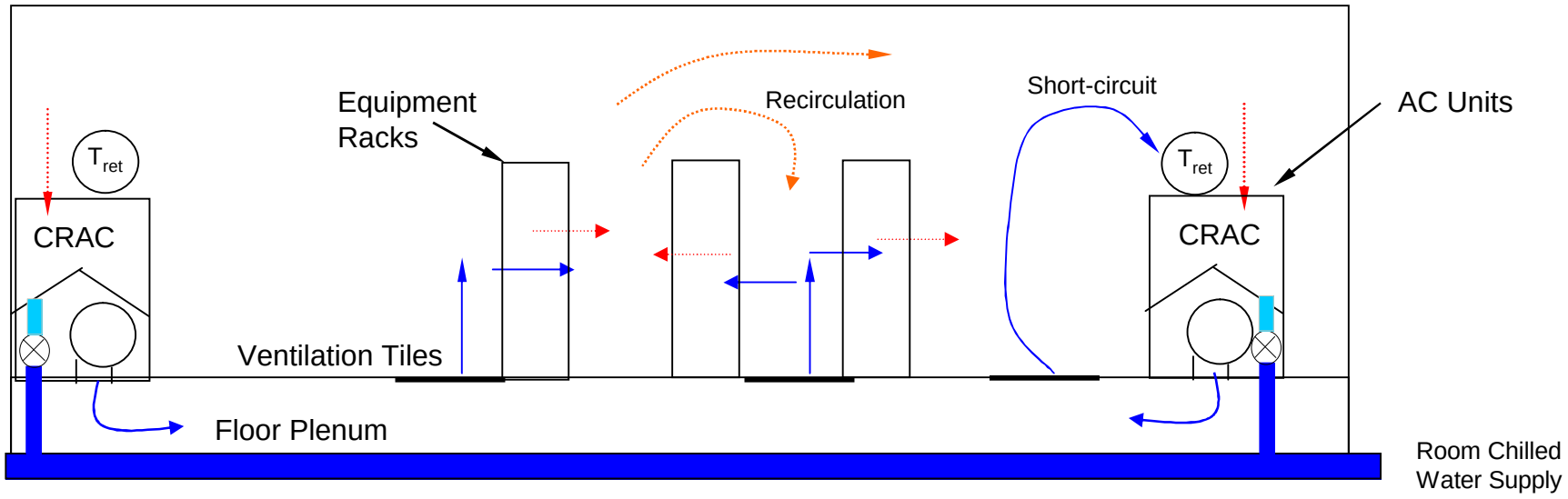
$$= \frac{\text{Heat Extracted by Air Conditioners}}{\text{Net total Work Input}}$$

# Smart Data Center Solution

- Policy Based Control engine for IT-facility environment
  - v works seamlessly with facility infrastructure
  - v compute, power, cooling resources are provisioned based on the need
- Sensing Infrastructure to monitor IT-facility environment
- Flexible building blocks spanning chips to cooling towers



# Conventional Data Center Control




- Mixing of hot and cold air streams;
  - Leads to re-circulation and short-circuiting of air.
- Intuition is used to deploy equipment and cooling resources;
- Single-input single-output environmental control;
  - Lack of information about local conditions.
  - Conservative set points à Inefficient operation and poor compaction.

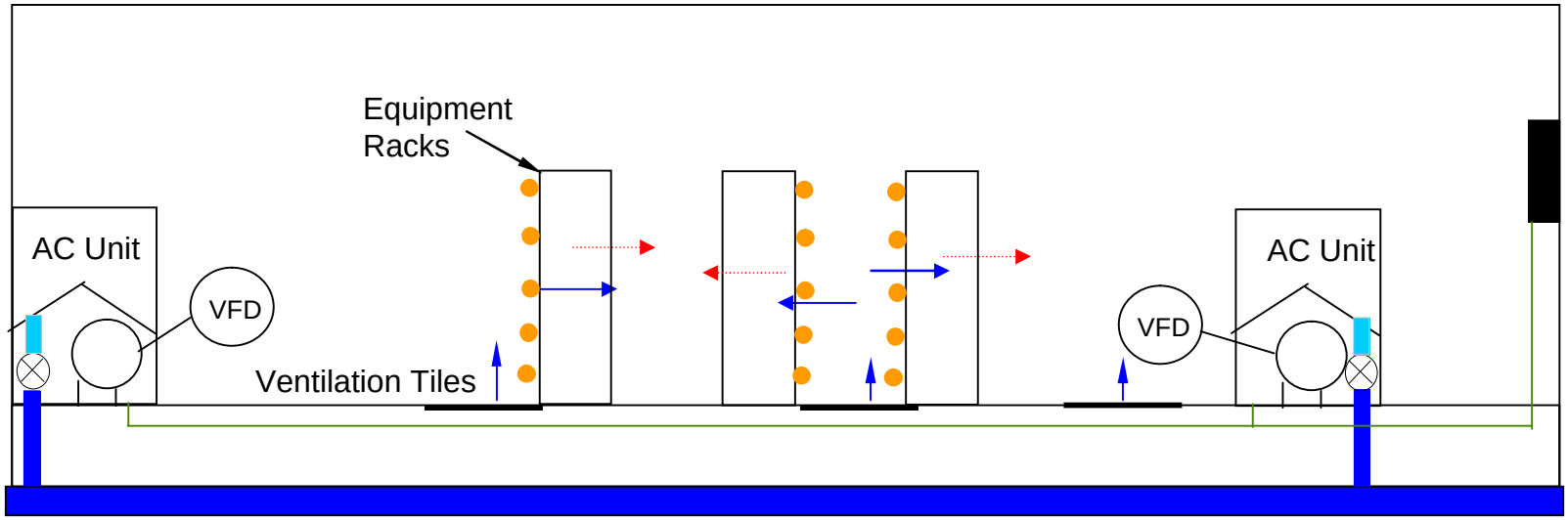
Addressed By:

**Static Smart Cooling and Good DC Design**

**Dynamic Smart Cooling**

# Cooling Architecture

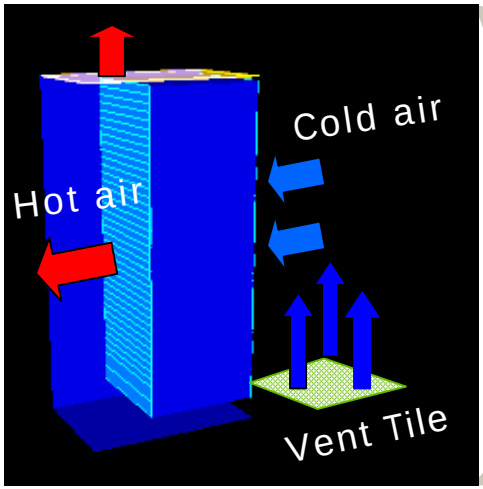
## Flexible Air Conditioning, Sensing, Control (Dynamic Smart Cooling)




- CRAC temperature control sensors moved from return to supply side;
- Variable Frequency Drives added to AC units;
- Chill Water valve under control
- Temperature sensors added to racks
- Advanced algorithms control operation of AC units.

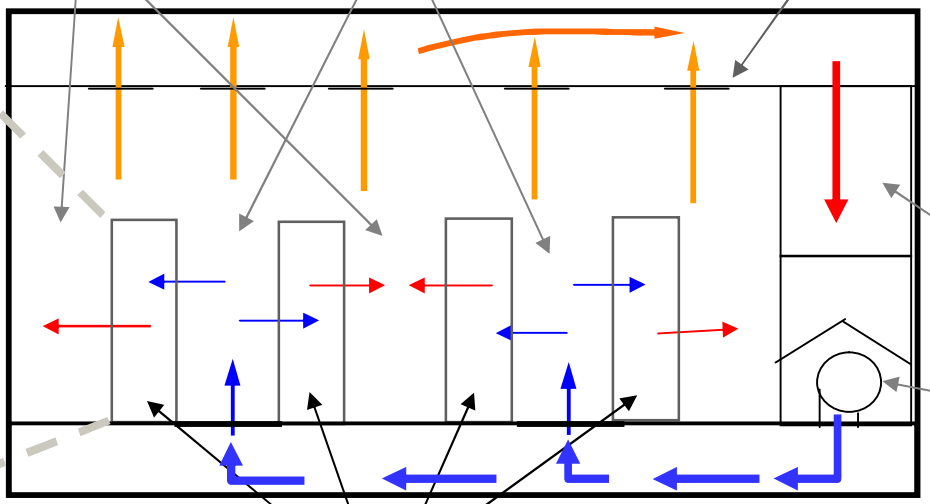
# Air Flow within Data center

## Rack Air flow



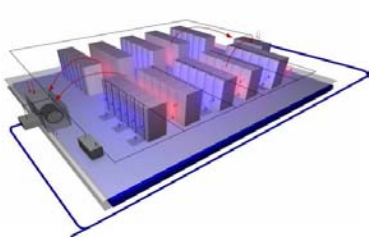

Cold Air
Hot Air

## Data Center Air flow




Cold Air
Hot Air

# Datacenter with DSC



1. Reducing the energy required to cool a datacenter can result in significant reduction in CO2 emissions
   - Green IT (Design-for-Environment - DFE)
2. Power and cooling costs limit scalability of the data center and consume large share of budget resources
   - Opex
3. Advances in compute density, such as blade servers, have resulted in highly dense servers that require significantly more power and cooling than traditional server configurations
   - Flexibility
4. The power and associated costs to cool the datacenter can be as much or more than the cost of powering the IT equipment (servers, storage and networking)
   - in majority of DCs upto 60% of power is associated with the power of cooling the IT equipment
     - Better computing / cooling power ratio

# Power and Compute Architectures

## Key Principles

Power architecture should integrate flexibility in resource design for power management, both in software and hardware.

Software techniques such as virtual machines or process migration or service migration can be used to move workloads to better optimize the power distributions to match the thermal profiles

Flexibility in the hardware design elements includes
system optimizations such as
disk spin down for storage,
turn entire systems on and off

At a data center level, this includes exploiting heterogeneity between different classes of servers to match workload requirements with resources

# More on HP Power and Cooling solutions

- More details on DSC available at, www.hp.com/go/dsc
- HP's Energy Efficiency for enterprise link, http://h71028.www7.hp.com/ERC/downloads/4AA1-4271ENW.pdf
- Online video on DSC and Power & Cooling solutions available at,
- http://hp.feedroom.com/index.jsp?fr_story=fb2c3aeb80e47cd4193c0c1883a692f82c5f93df&fr_chl=5c1c8e78c02a6c9a017651149320eb1a6e4b3b86

  http://h71028.www7.hp.com/enterprise/cache/434556-0-0-0-121.html